Weather Forecasting

GEOG/ENST 3331 – Lecture 8

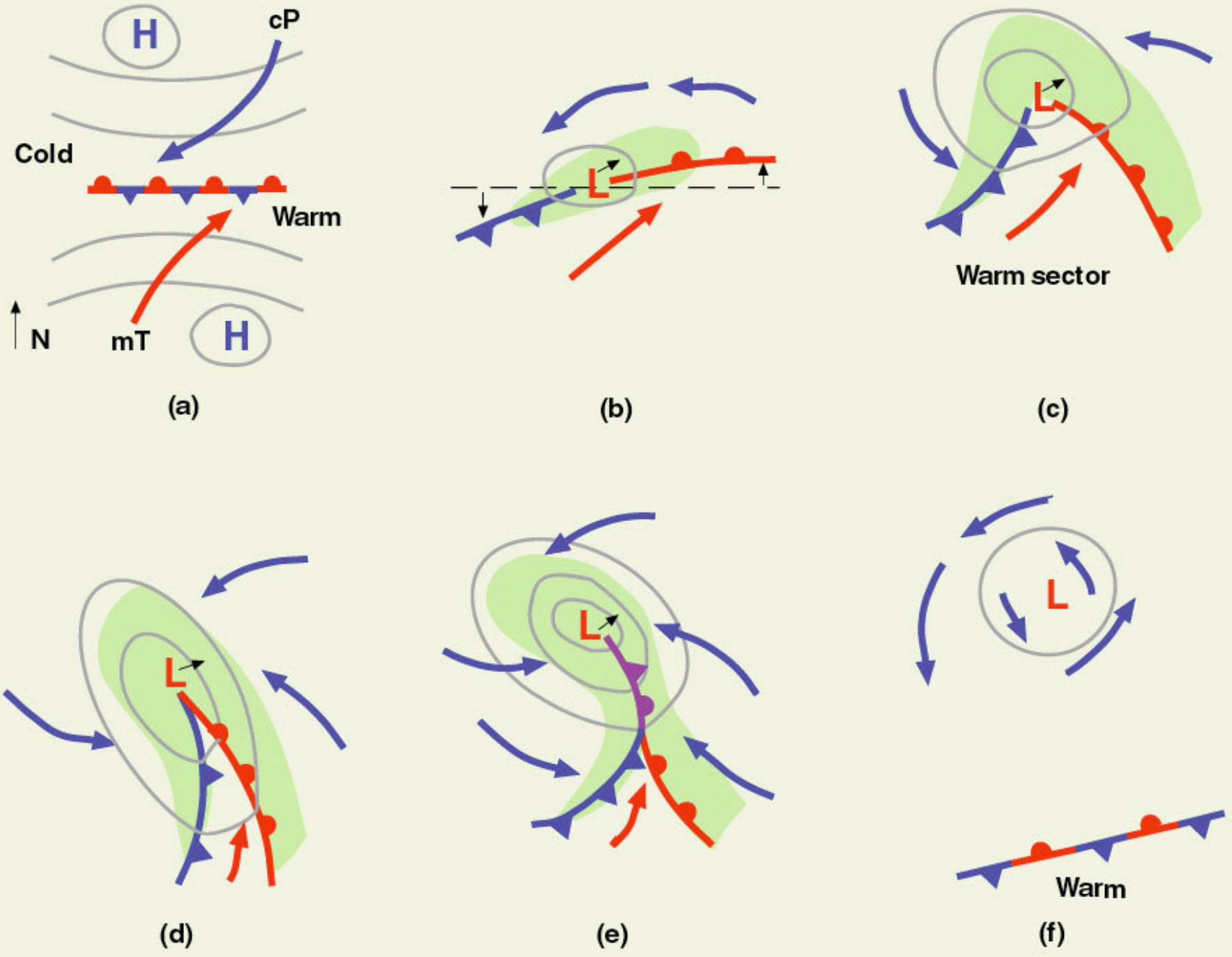
Ahrens: Chapters 12 and 13; A&B: Chapters 10 and 13

Assignment 3

- Continents cause small-scale circulations (land/sea breezes) due to differential heating. How do continents affect global circulation patterns?
- How does the global circulation lead to the development of the polar jet stream?

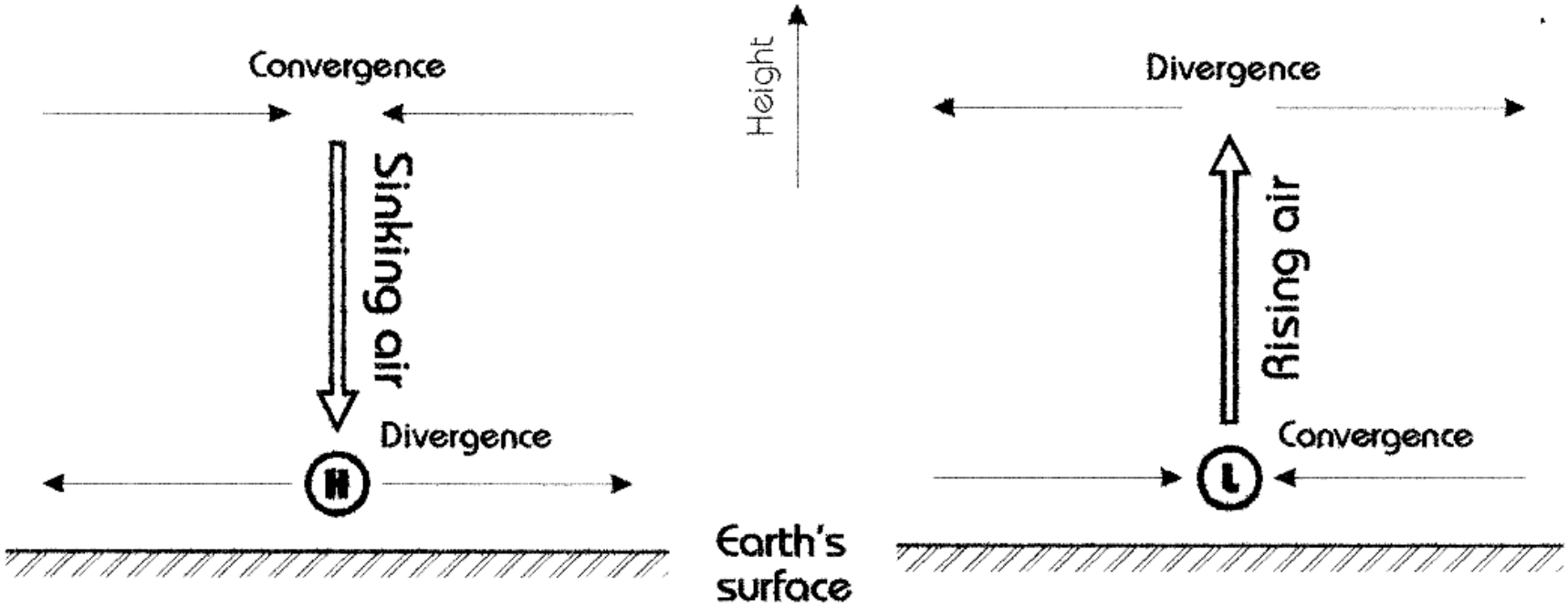
Lecture Objectives

- Examine theory for midlatitude cyclogenesis
- Analyze techniques for weather forecasting
  - History
  - How they are performed
  - Appropriate timescales

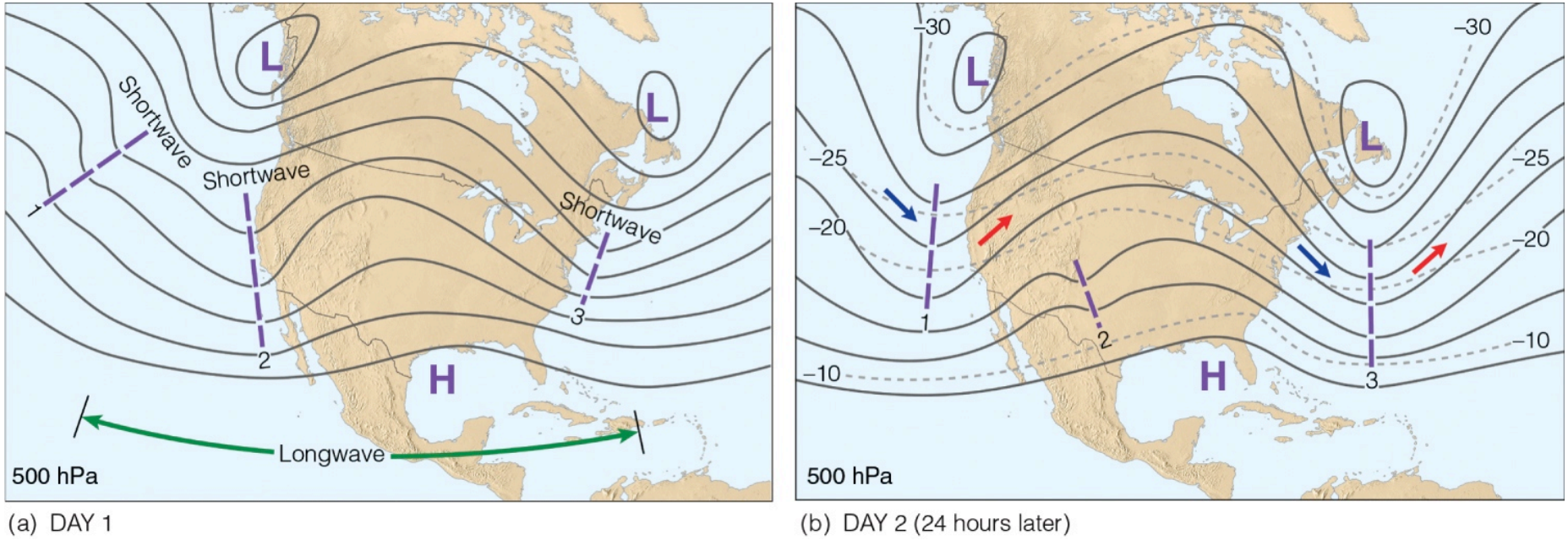


Ahrens: Figure 12.1

Surface winds and vertical motion

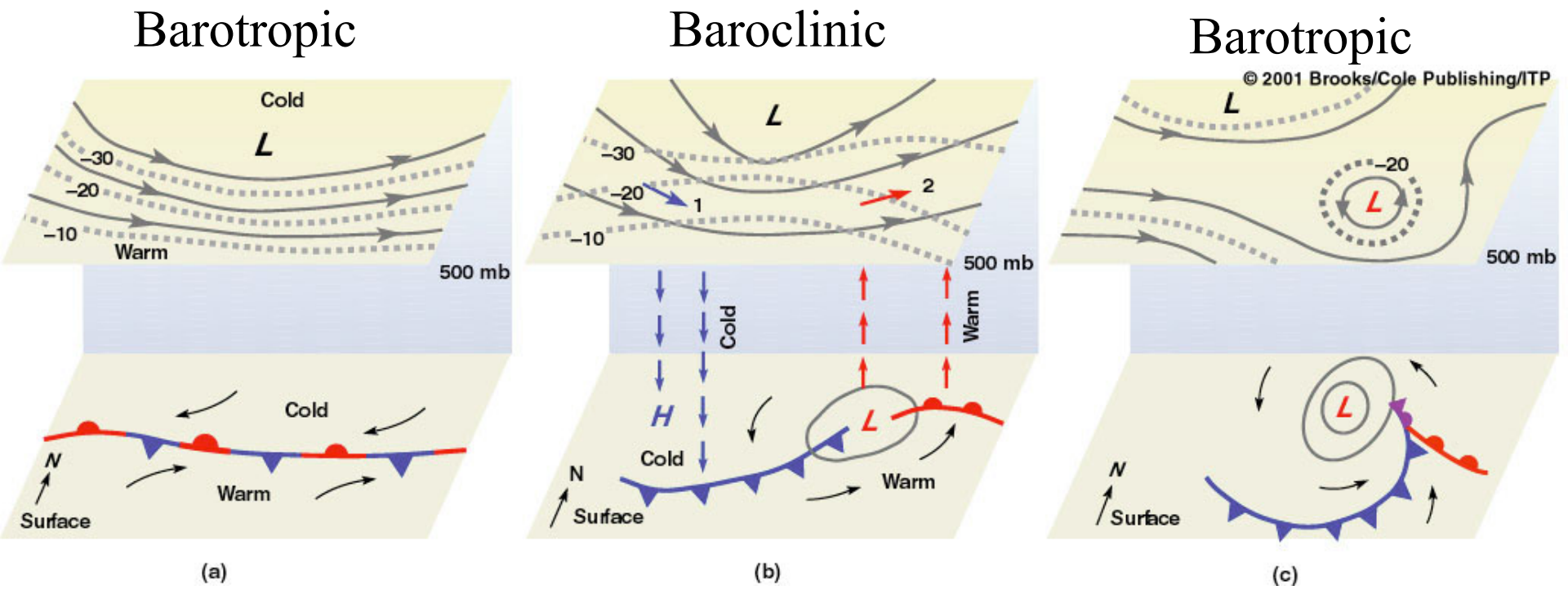


Shortwaves and longwaves



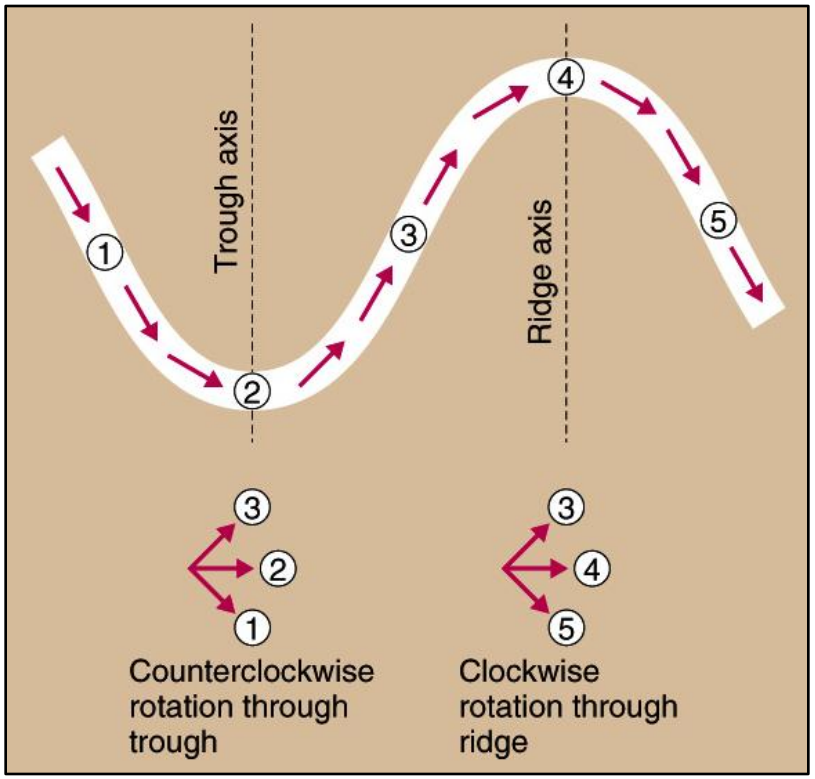
Ahrens: Active Fig. 12.9

Development of a Baroclinic Wave



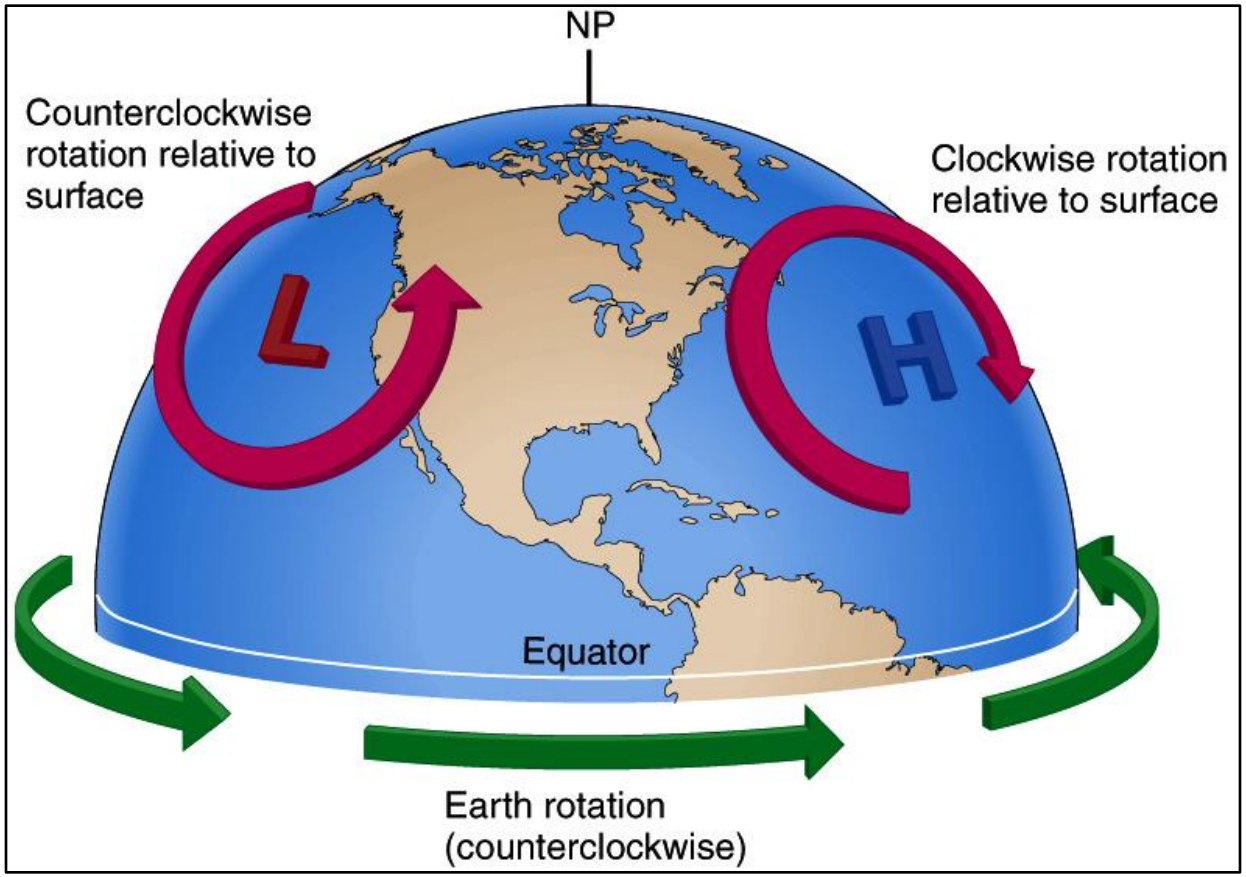
Vorticity

- Rotation of a fluid
- Changes direction between troughs and ridges



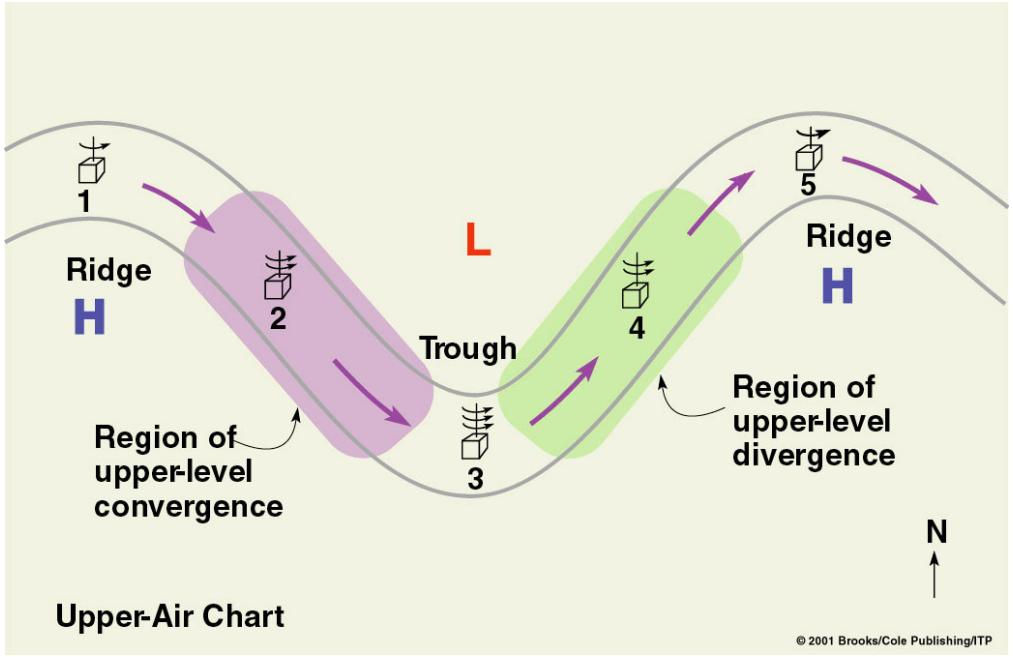
A&B: Figure 10-4

Positive and negative vorticity



A&B: Figure 10-5

Angular momentum: $mv_1r_1 = mv_2r_2$

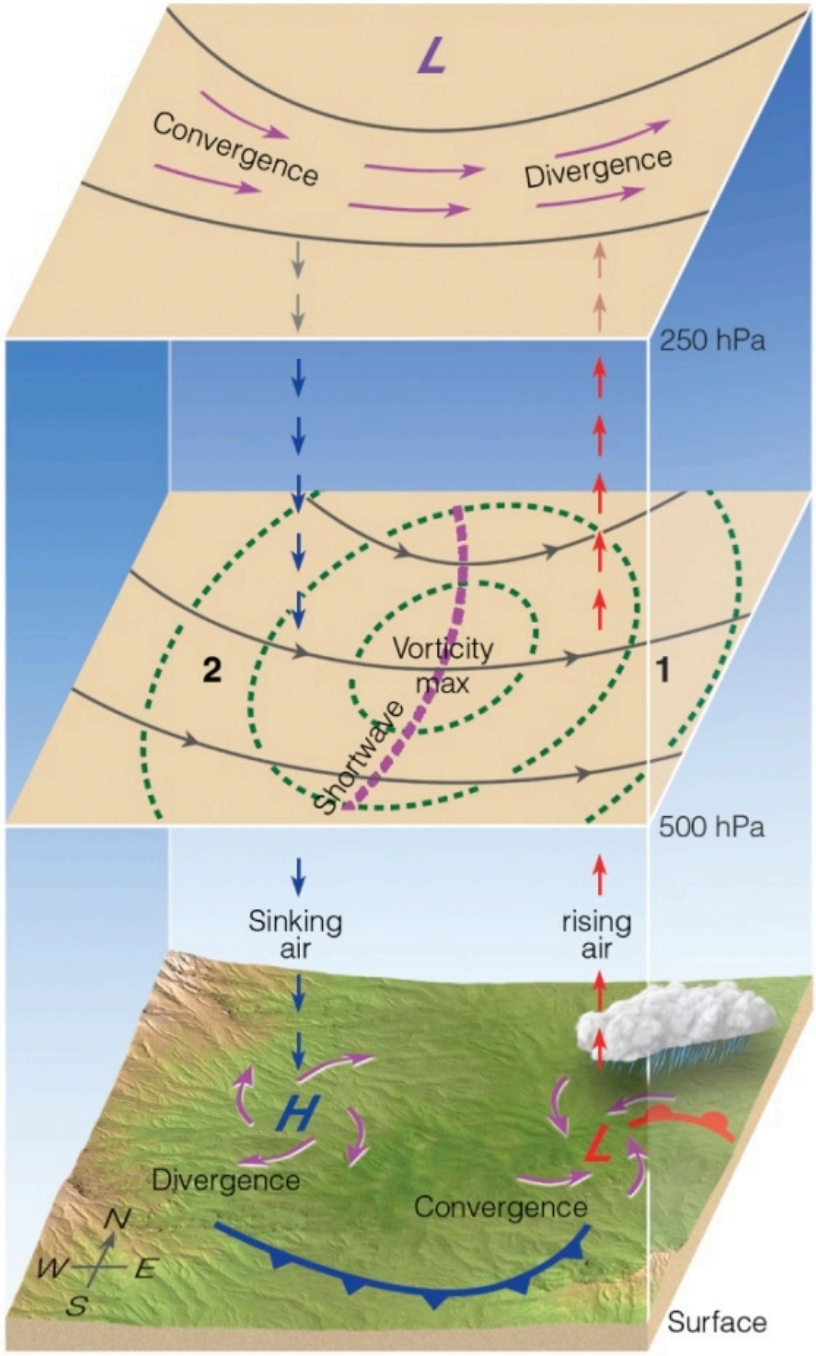


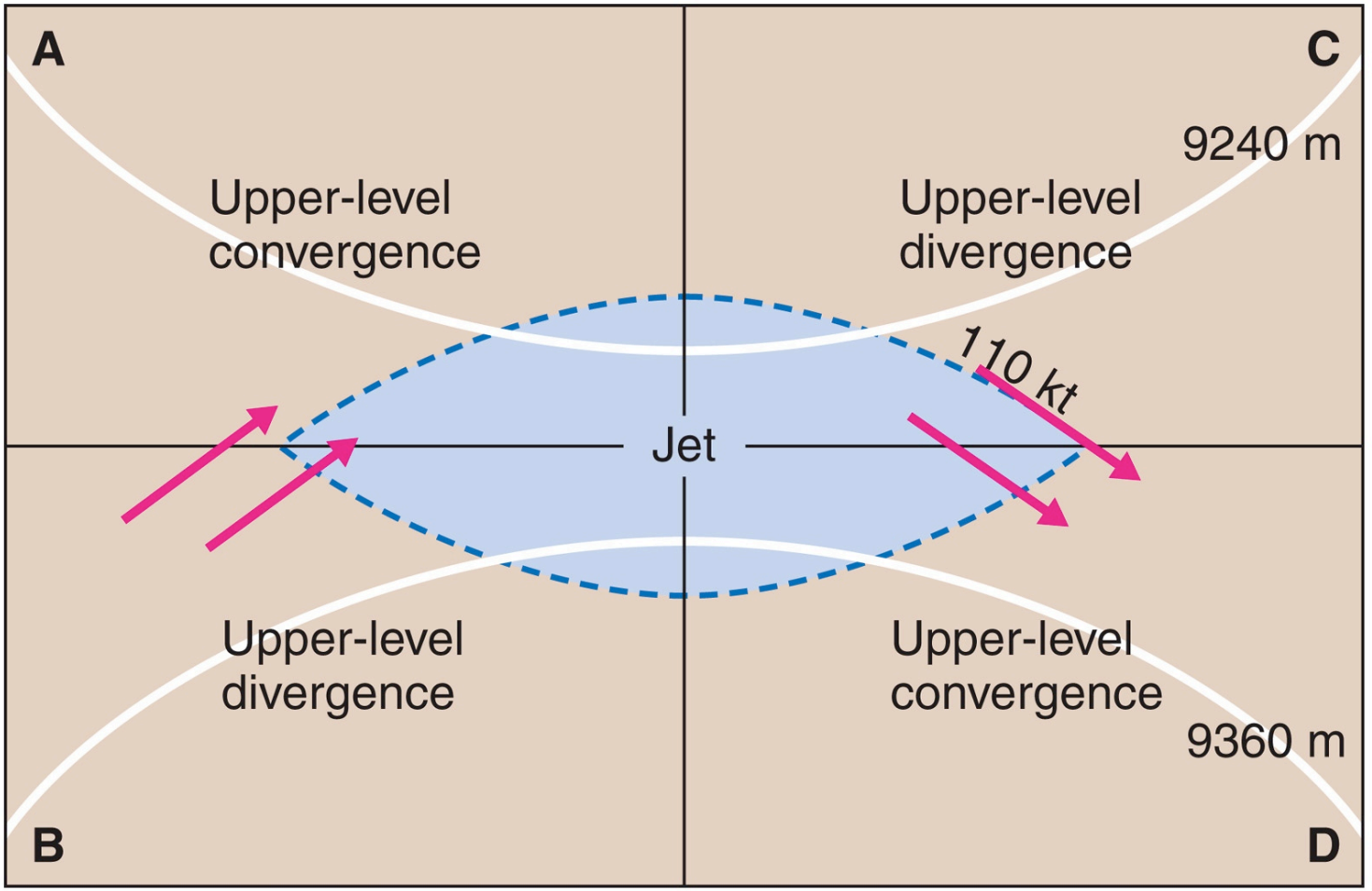
- As the spin increases, the air is pulled together more tightly and so converges.
- As the spin decreases, the air spreads apart and so diverges.

Ahrens: Fig. 12.23

Vorticity and storms

Ahrens: Fig. 12.24



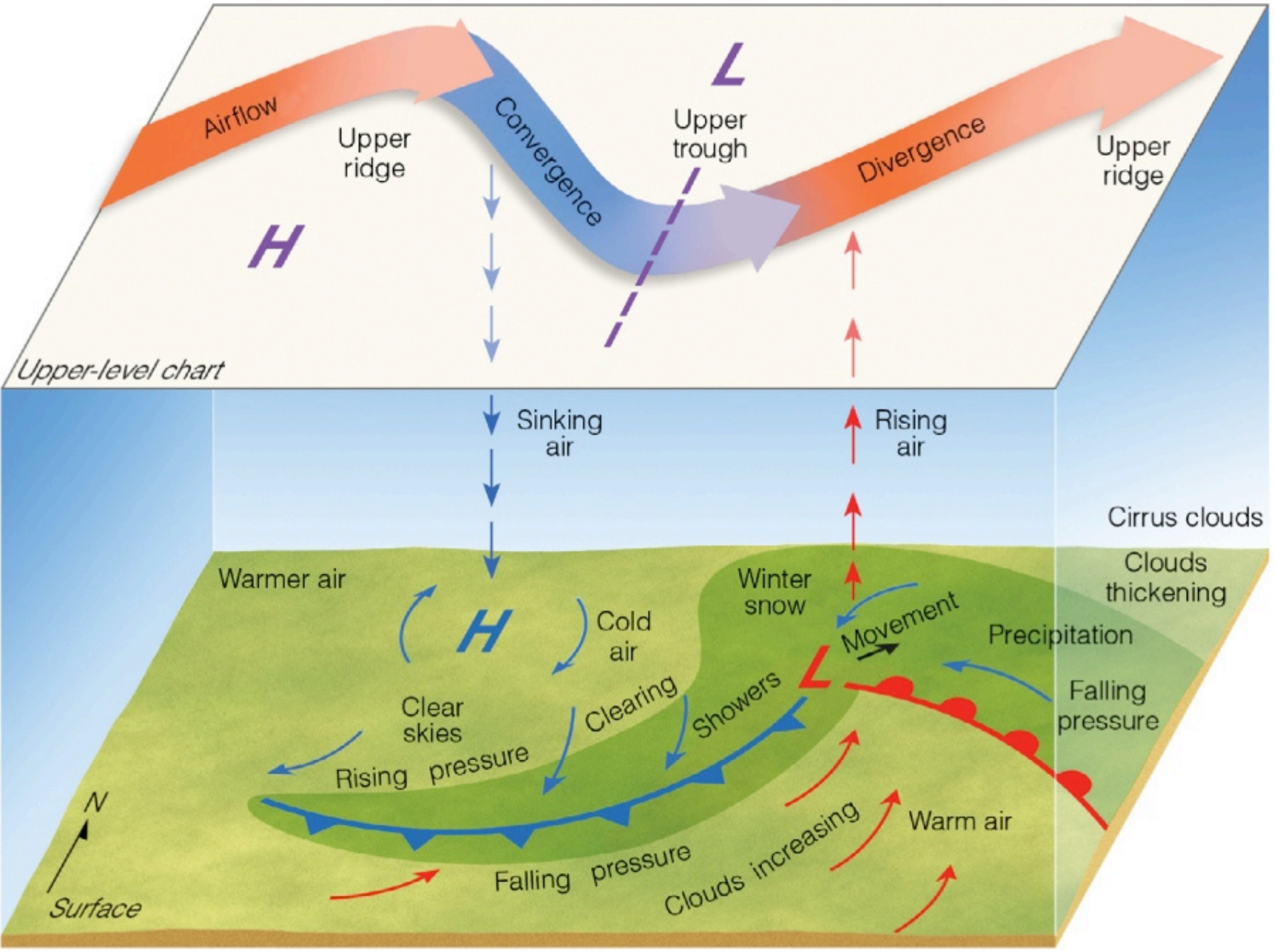


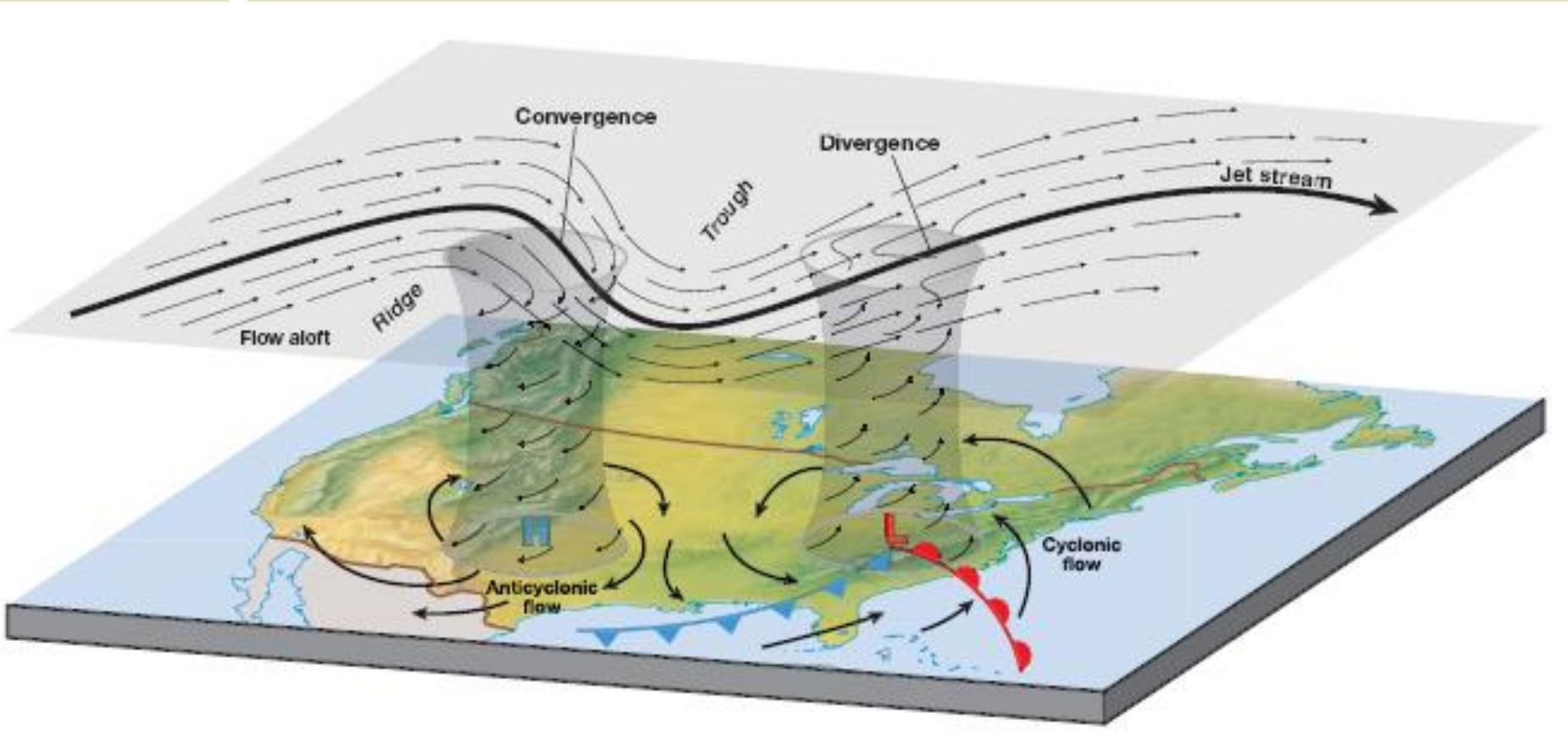
Jet streaks and upper air convergence

Where isobars draw closer together wind speed is greatly increased

A pattern of convergence and divergence appears (NH)

A&B: Figure 13-20


Airflow
Upper ridge
Convergence
L
Upper trough
Divergence
Upper ridge
H
Upper-level chart
Sinking air
Rising air
Cirrus clouds
Warmer air
H
Cold air
Winter snow
Movement
Clouds thickening
Precipitation
L
Falling pressure
Clear skies
Clearing
Showers
Rising pressure
N
Surface
Falling pressure
Clouds increasing
Warm air

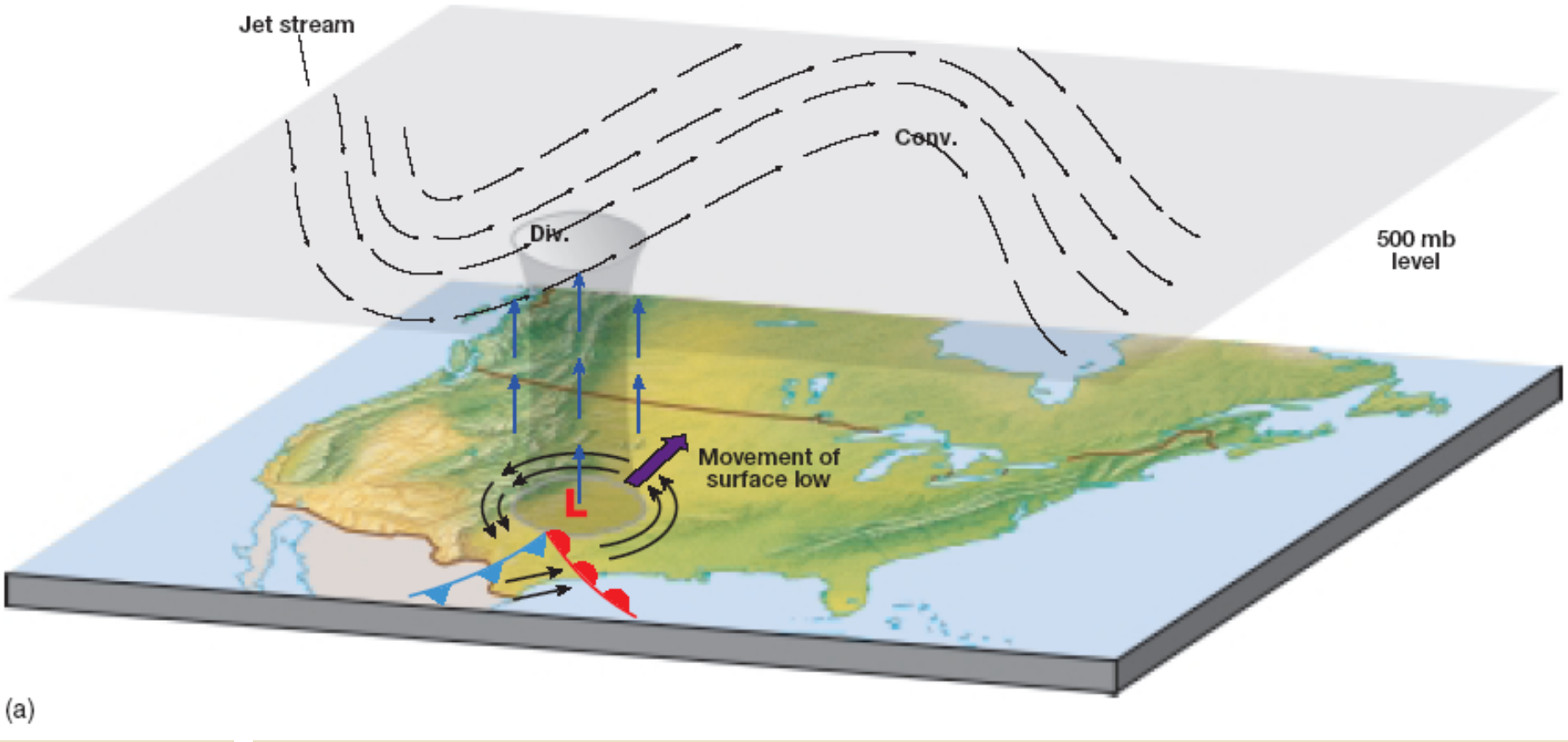


Dynamic pressure systems

Cyclones form in areas of upper-level divergence

Path of the cyclone most frequently follows the course of upper level flow

A&B: Figure 10-7

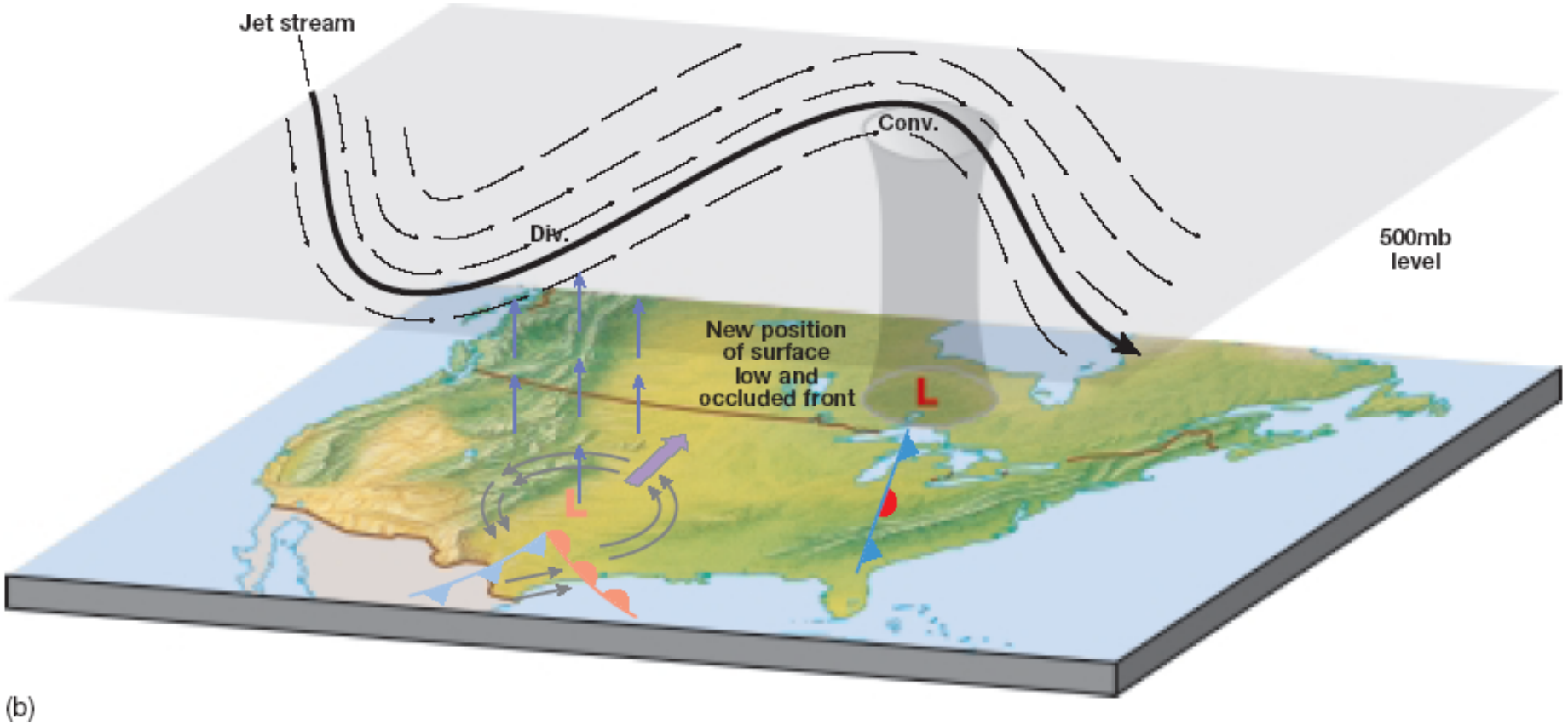


Dynamic pressure systems

Uplift maintains or strengthens cyclone.

Cyclone will follow the path of upper air divergence.

A&B: Figure 10-17



Dynamic pressure systems

Sinking air helps to fill in the low.

A&B: Figure 10-17

Upper air charts

- Pressure used as the vertical coordinate
- Height
  - Isoheight or isohypse
- Temperature
  - Isotherm
- Vorticity
- Wind speed
  - Isotach
- Pressure tendency
  - Isallobar

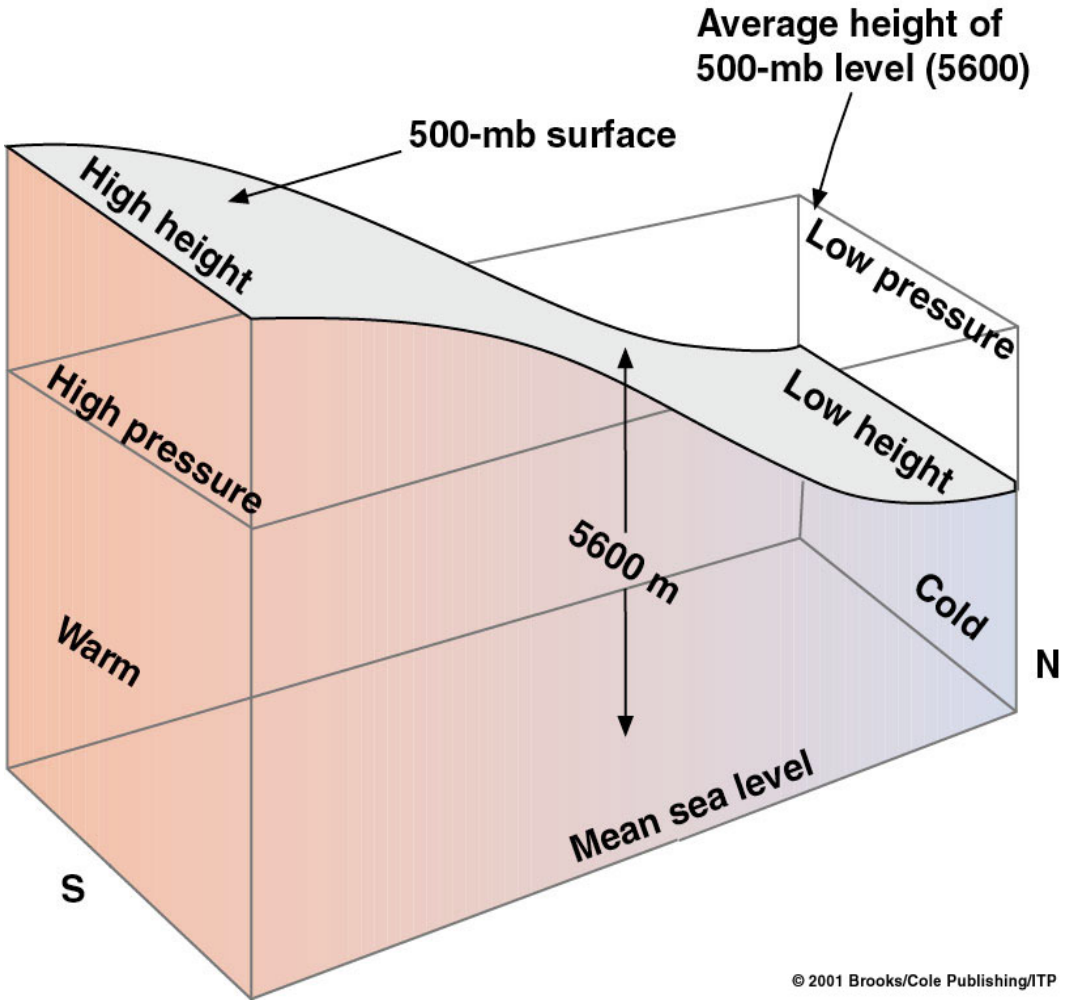
Pressure Surface	Approximate Altitude
850 hPa	1.5 km
700 hPa	3 km
500 hPa	5 km
250 hPa	10 km

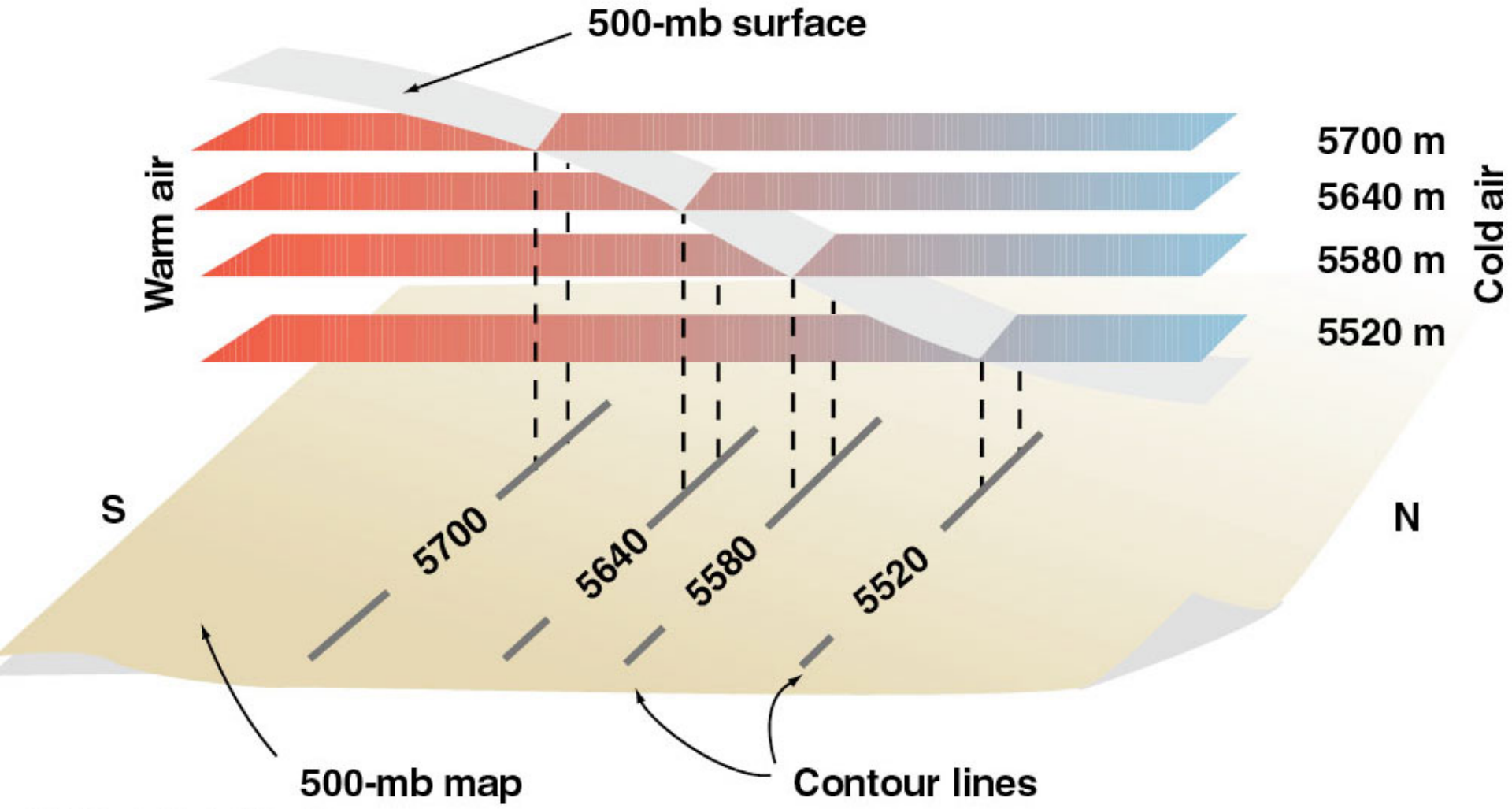
Meteorological Charts

Height vs. pressure

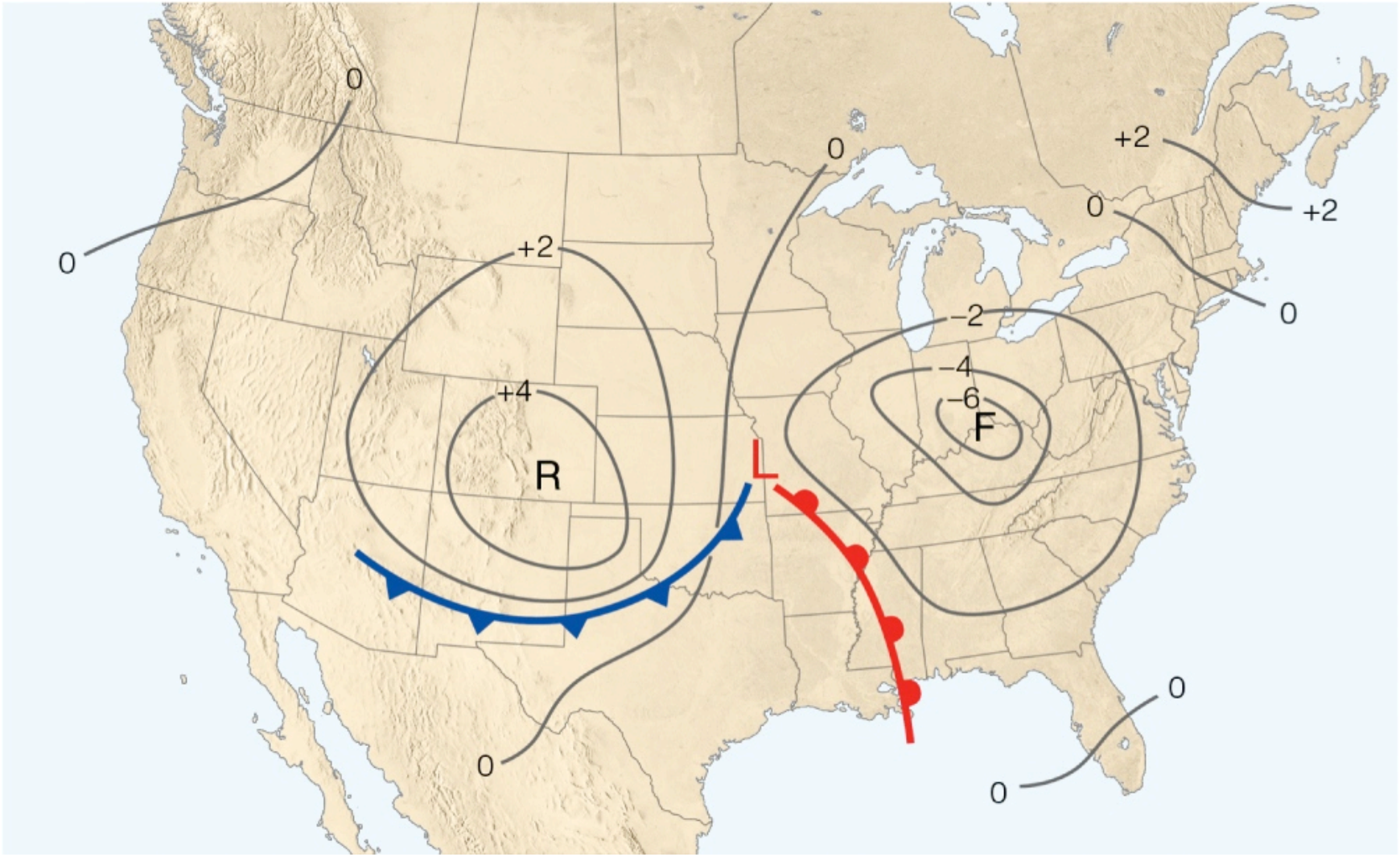
Surface maps use pressure as the variable measured at constant elevation (sea level)

Upper air charts are on constant pressure surfaces.

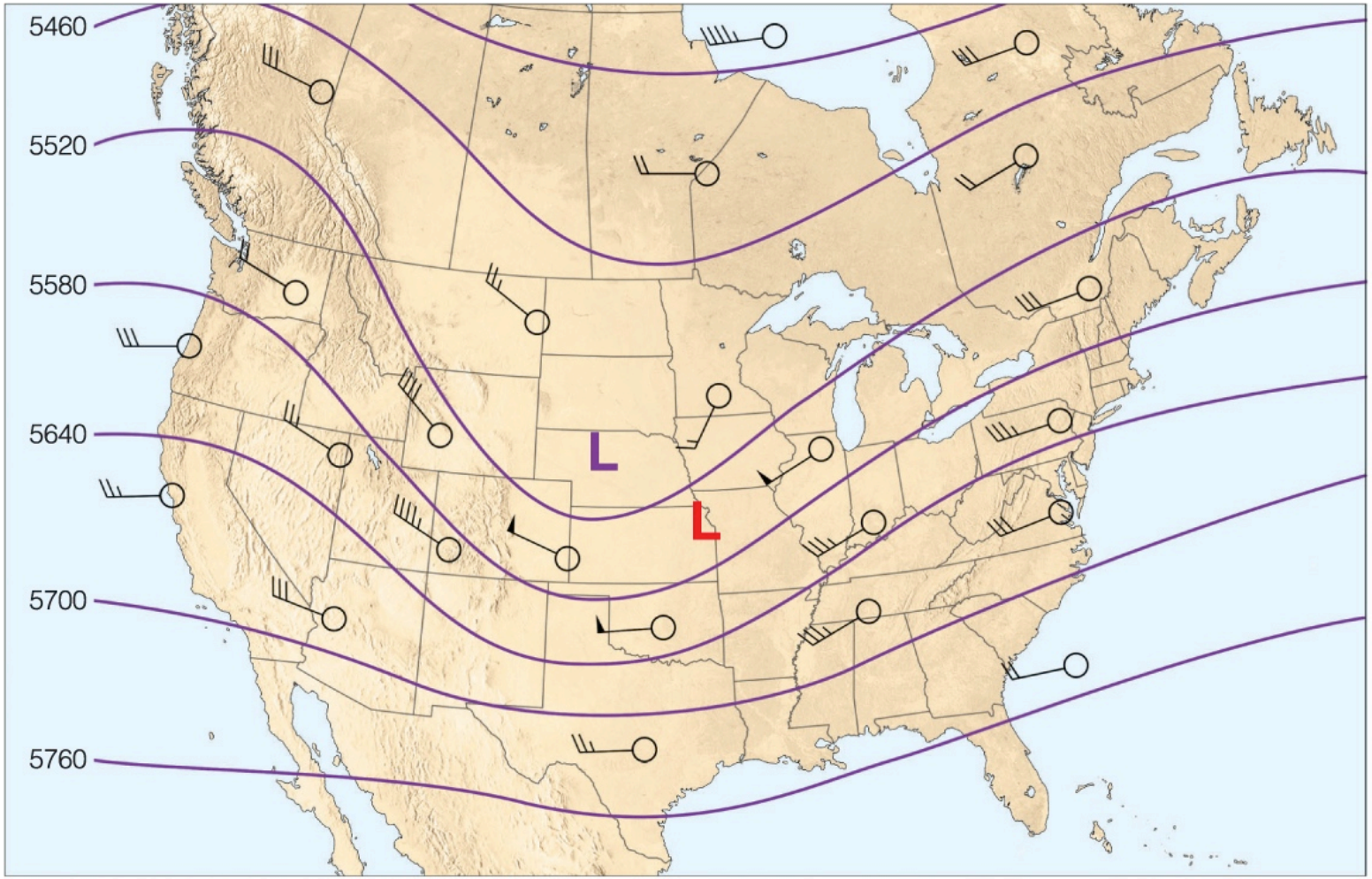




Isallobars (hPa/3 hours) on a surface chart

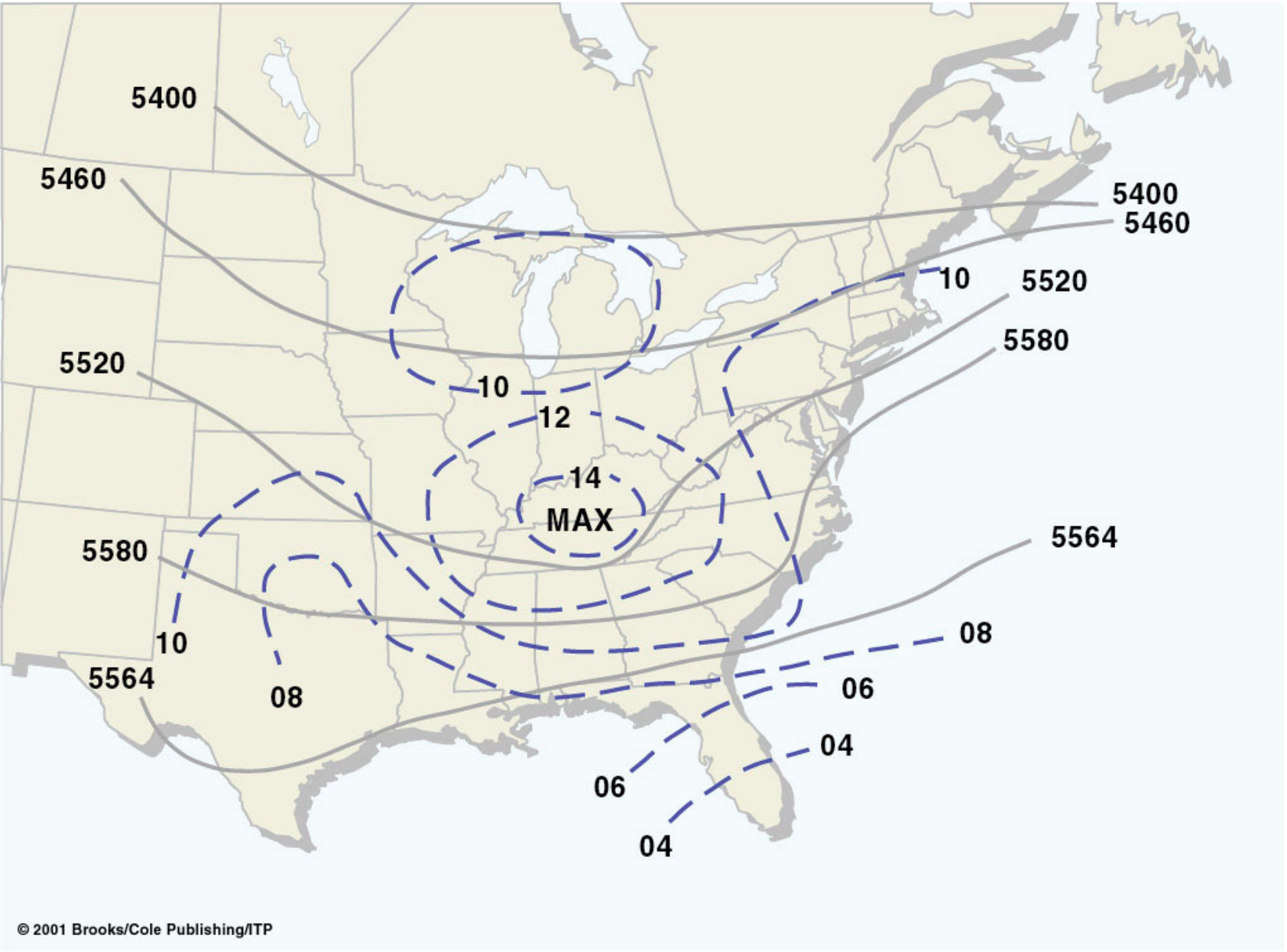


Ahrens: Fig. 13.14



	km h^{-1}	Knots
	Calm	Calm
	1–3	1–2
	4–13	3–7
	14–19	8–12
	20–32	13–17
	33–40	18–22
	41–50	23–27
	51–60	28–32
	61–69	33–37
	70–79	38–42
	80–87	43–47
	88–96	48–52
	97–106	53–57
	107–114	58–62
	115–124	63–67
	125–134	68–72
	135–143	73–77
	144–198	103–107

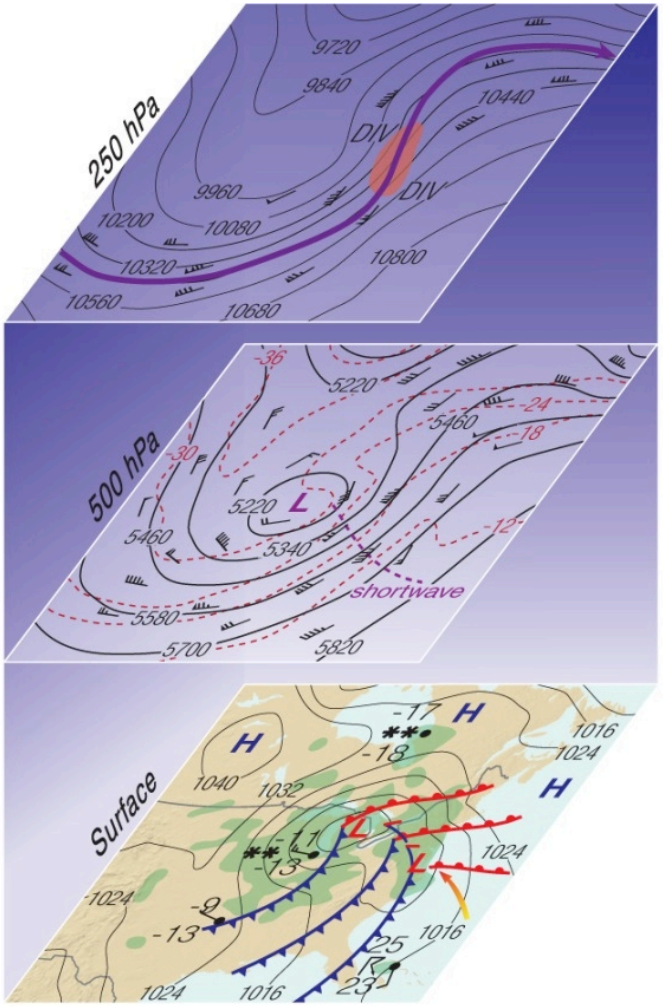
Ahrens: Fig. 13.15
500 hPa chart with isohypses (m) and wind flow
Red 'L' is the surface low pressure

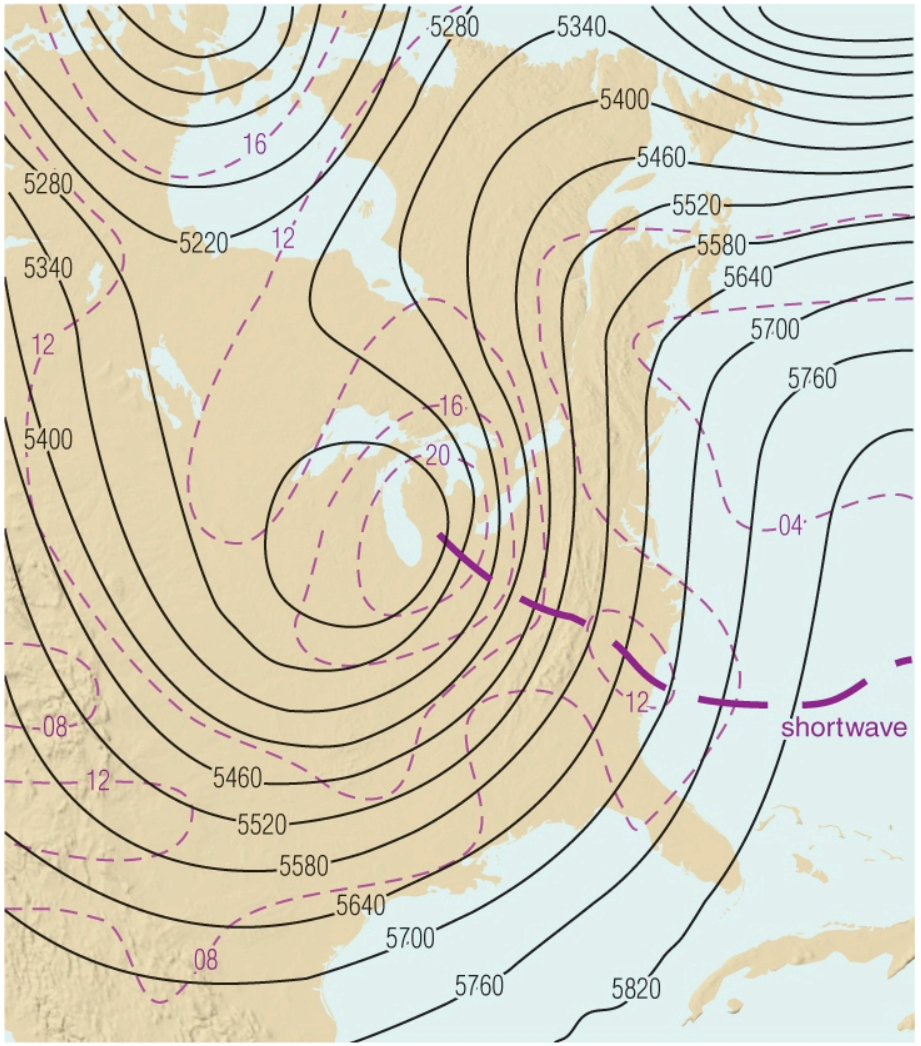


500 hPa chart with lines of constant vorticity (10^{-5}/s)

Upper air charts

Ahrens: Figs 12.26 and 12.27





Weather forecasting

- Take observed conditions and predict future ones
- Forecast quality
  - Agreement between forecast and observations
  - Accuracy
- Forecast value
  - Usefulness
  - Skill: improvement over other methods

Folklore

When halo rings the moon or sun;

Rain's approaching on the run.

Folklore

Mackerel sky and mare's tails make lofty ships carry low sails.

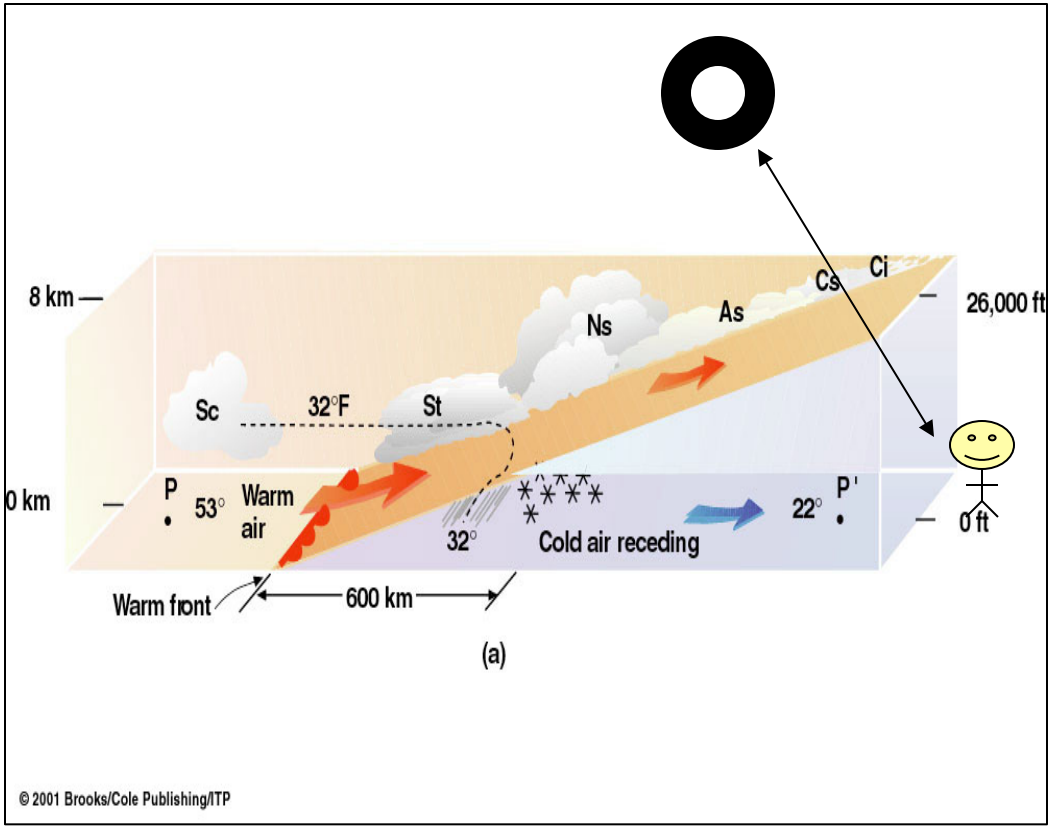
Folklore

Halo around moon or sun

- caused by ice crystals
- high altitude clouds
- forerunner of a midlatitude cyclone

Mackerel sky/mare's tails

- more high clouds
- forerunner of a midlatitude cyclone

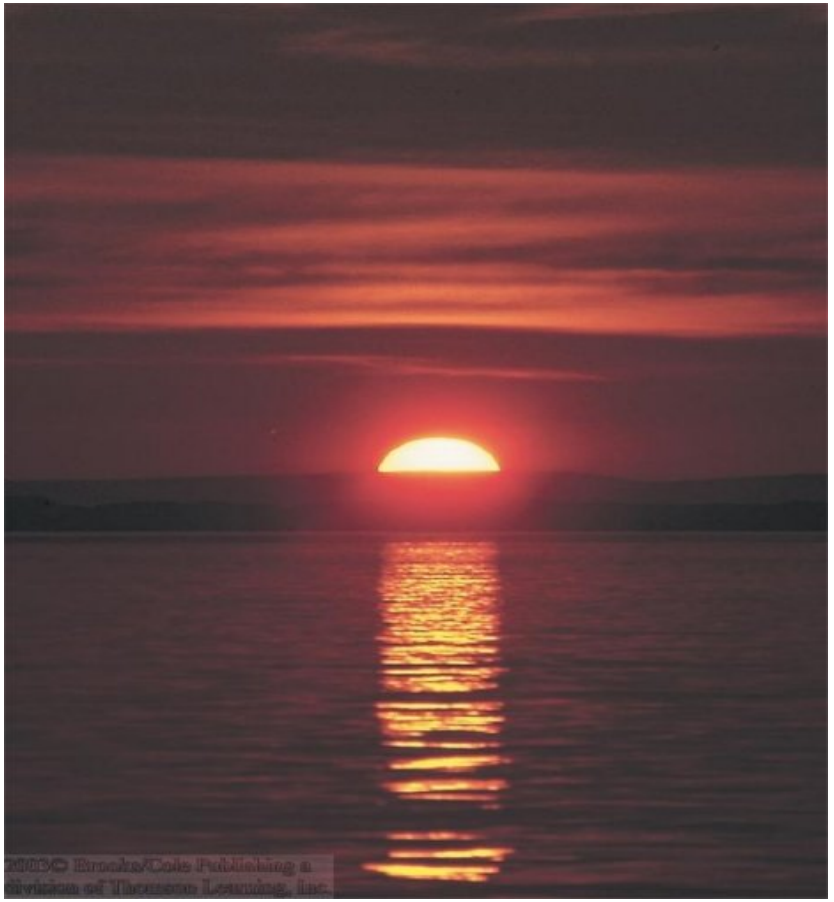


Folklore

Red sky at night, sailors delight;

Red sky in morning, sailors take warning.

Also in the Bible (Matthew 16:3)



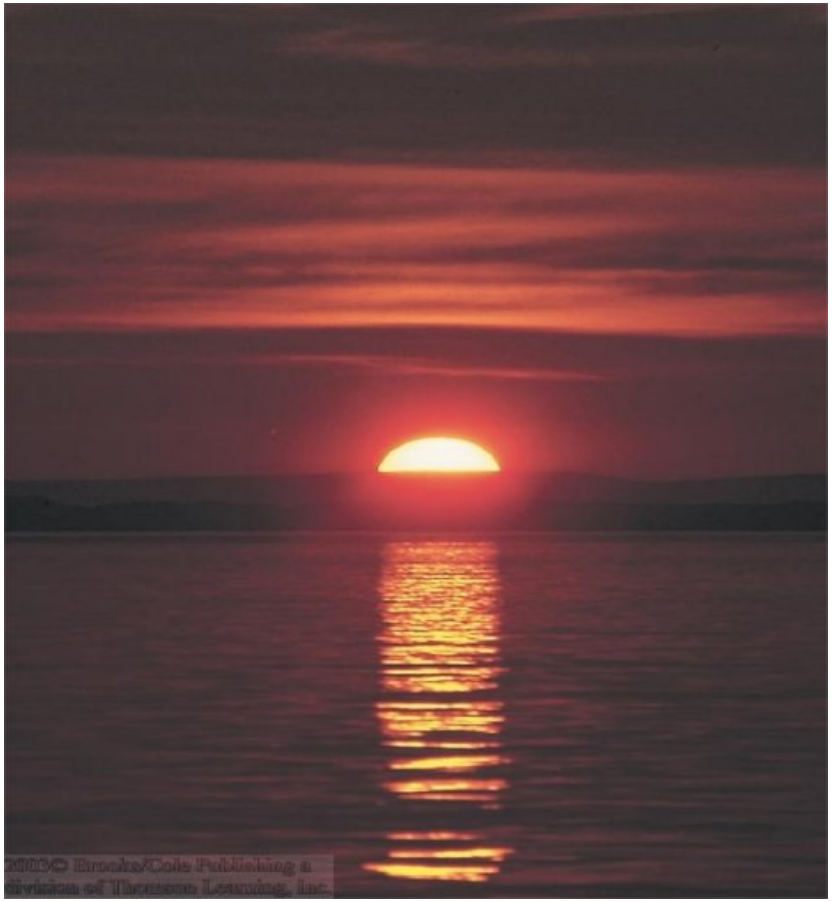
Folklore

Sun sets in the west

- Shines through clear skies to light up clouds overhead
- Red sky at night

Sun rises in the east

- Lights up clouds moving in from the west
- Red sky in morning



Weather Forecasting

Persistence

- The weather will remain as it is
- Good for short forecasts - best for under 12 hours
- No skill: baseline for comparison with other forecasts

Tendency

- Surface weather system continues to propagate at same speed and in the same direction

Weather Forecasting

1854 – first modern day forecasts

Captain Robert FitzRoy, London

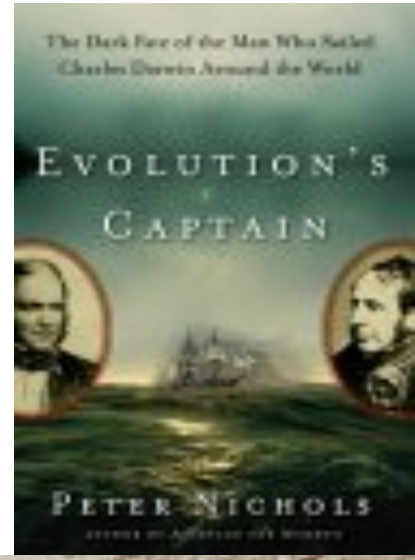
Captain of the HMS Beagle *(Darwin)*

Briefly governor of New Zealand

1860 – first daily weather forecast

Mixed success, heavily criticized

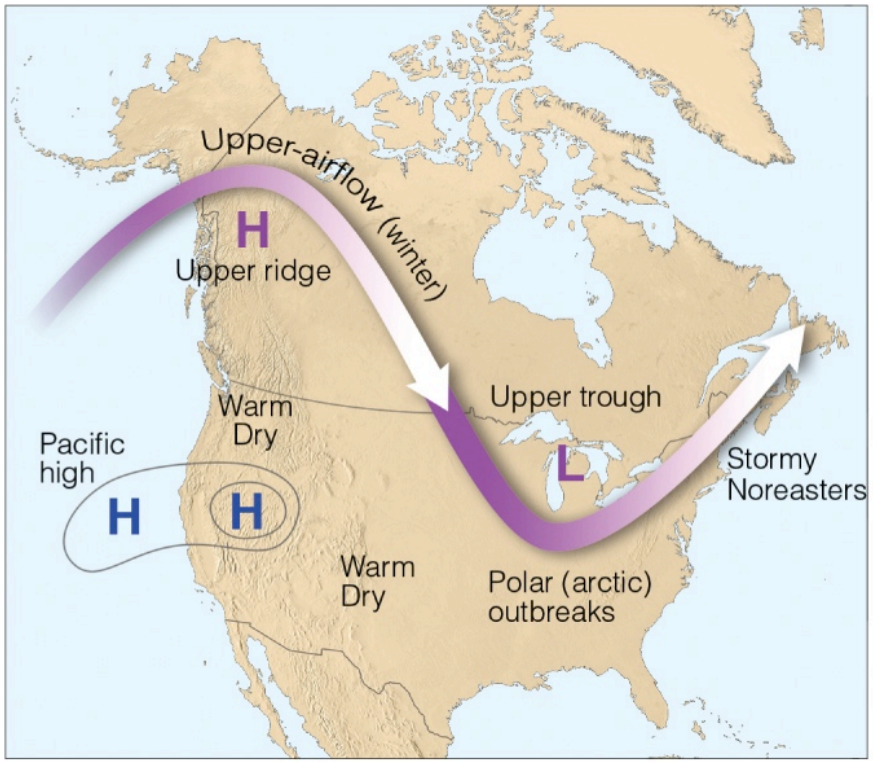
Suicide in 1865 at age 60



Weather Forecasting

Analogue

- Compare patterns to past events
- General large scale circumstance leads to typical weather

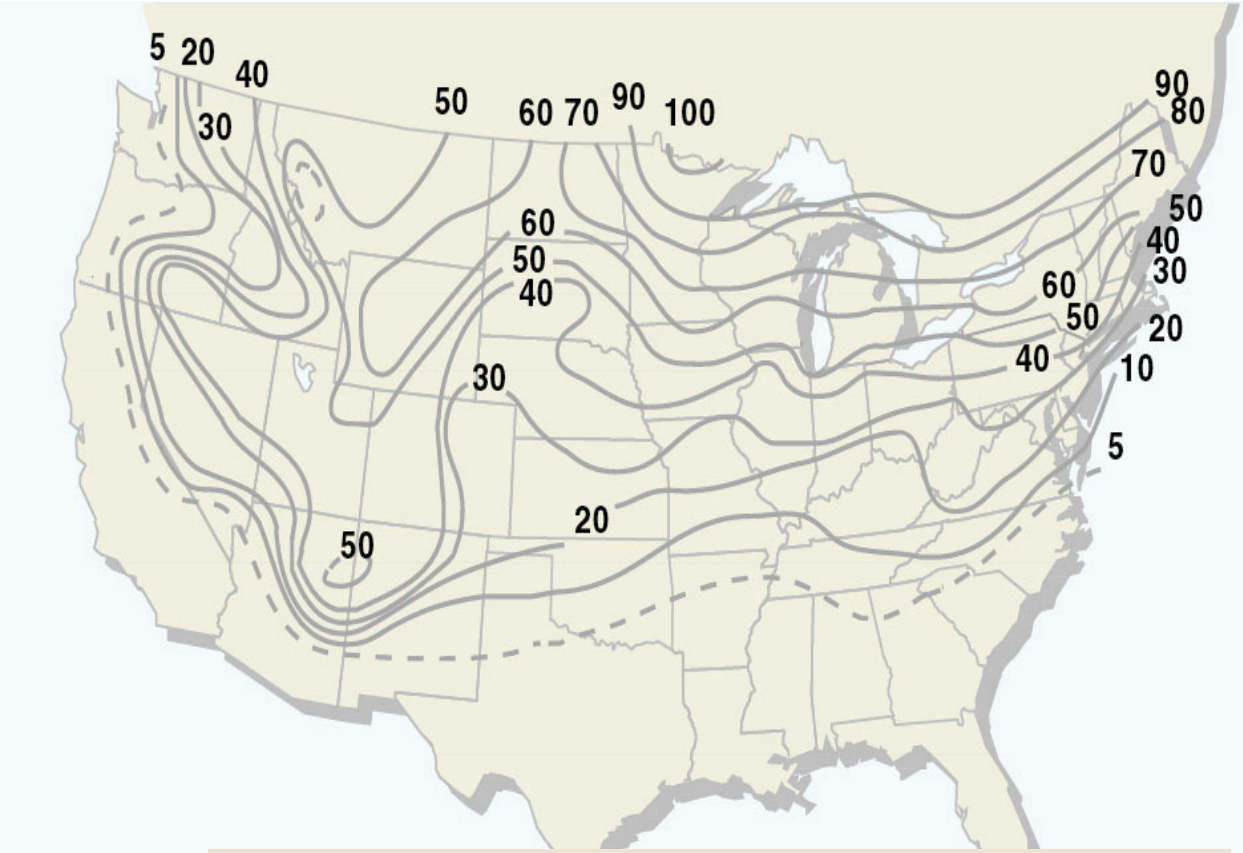


Ahrens: Fig. 13.8

Weather Forecasting

Climatology / Probability

- use of 30 year means
- best forecast for two weeks or greater
- method of choice in the weather insurance industry



Percent likelihood of snow coverage– Dec. 25

Weather forecasting (so far)

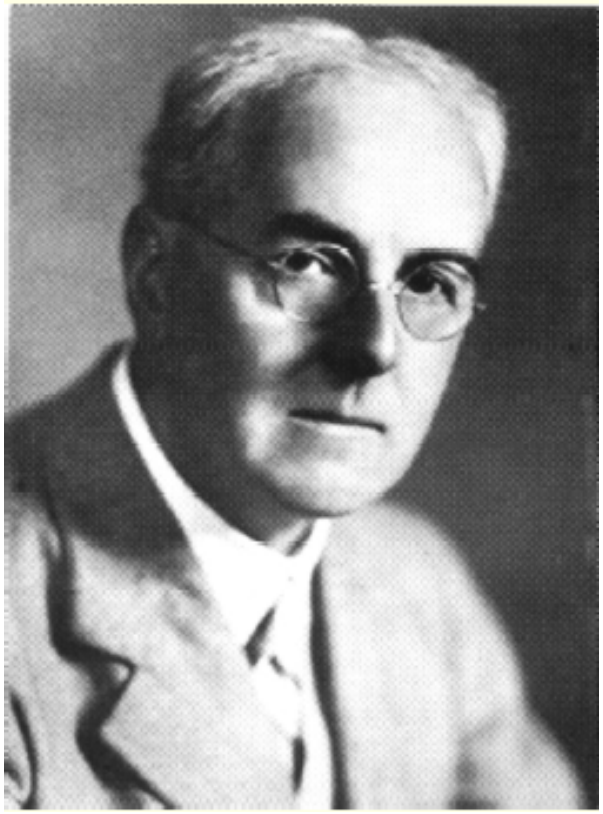
- Persistence
- Tendency
- Analogues
- Climatology

Weather Forecasting

Numerical forecasting history

- L.F. Richardson, 1922
- Used simplified set of equations

- Six weeks for six hour forecast (or use 60,000 people to produce forecast on time)
- Forecast was quite poor due to the simplistic physics and poor initialization data.



Weather Forecasting

Numerical forecasting history

- 1940's advent of the computer (John von Neumann)
- Better theoretical framework
  - Jule Charney: baroclinic instability and planetary wave vorticity
- More realistic forecasts were made in a timely fashion.

Numerical weather forecasting

- Three requirements
  - Conceptual framework - set of mathematical equations to predict temperature, pressure, moisture, wind
  - Initialization data
  - Fast computers

Next Lecture

- Numerical weather forecasting
- Ahrens: Chapter 13
- Aguado and Burt: Chapter 13